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ABSTRACT

This paper provides information and strategies to reduce the risk of encountering an avalanche when skiing or climbing on steep slopes. Skiers must recognize that the risk exists, be aware of their own tolerance for risk, and not allow companions to pressure them into taking more risk than they can tolerate. Ideally, one should ski with a small group of similar ability and similar risk tolerance. Four is a good group size--small enough to be manageable and large enough to deal with avalanche rescue. A good skier making smooth turns stresses the slope less than a falling skier. Basic safety tips include carrying and knowing how to use basic safety and rescue equipment, skiing familiar slopes, making a habit of forming an opinion about snow stability, listening to weather and avalanche forecasts, and waiting for the right conditions. "Snowcraft" entails observing and storing minute details to build up a picture of snow conditions. Some things to look for are evidence of avalanching, wind direction, aspect of the slope to sun and wind, texture of the snow surface, feelings of settling underfoot, and the way the skis move through the snow. Instructions are provided for various tests of snow stability: ski pole test, digging a snow pit, shovel shear test, compression test, loaded column test, and Rutschblock test. Procedures for stability evaluation are summarized, and suggestions are offered for managing groups of skiers and for skiing safely and with the least stress to the slope. (SV)

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Reducing the Odds Backcountry Powder Skiing in Avalanche Terrain

Tony Daffern
Rocky Mountain Books

Abstract—This paper addresses the needs of the backcountry powder-hound who deliberately seeks deep powder in avalanche terrain. While we can take some comfort from the statement made by avalanche guru Ed LaChapelle that "the snow is stable 90% of the time", there will always be risk when skiing steep slopes in the backcountry. How can you reduce the risk to an acceptable minimum while still enjoying a good day's skiing? If you are a serious deep-powder hound you will learn to distinguish the good days from the bad, to observe current snow conditions, to evaluate snow stability from a few simple tests, to recognize signs of instability and perhaps the most important factor in reducing the odds, you will practice safe skiing techniques.

Risk

A discussion on evaluating snow stability would not be complete without some mention of risk. In the introduction to "Avalanche Safety for Skiers & Climbers " I state that "Only by recognizing risk can you use your knowledge and experience to reduce that risk". It can be further argued that whatever your personal acceptable level of risk the potential reward must always outweigh the risk. In other words don't stick your neck out for a run or two of lousy skiing. Save all your "nine lives" (hopefully more) for those occasional perfect days.

Everyone has a different tolerance for risk, from the risk-seeker who skis steep slopes regardless of conditions to the person with a low tolerance for risk who will only venture onto steeper slopes when the snowpack is indisputably stable.

When skiing with a large group or with companions who are better skiers, you should avoid being pressured into accepting more risk than you really want to tolerate. Be aware of your companion's attitude to risk and make adjustments on the conservative side if necessary.

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Your Skiing Companions

Your choice of skiing companions is an important factor in the pursuit of safe skiing. The riskier the skiing the more critical it is to know their skiing ability and experience, their tolerance for risk and their potential behaviour in an emergency. Ideally you should ski with a small group of companions of similar ability and with similar tolerance for risk. If you ski with a large group you will have to be much more conservative in your choice of slope as it is much more difficult to apply principles of safe skiing to a big group.

The ideal group size is one which is small enough to be manageable and large enough to be effective in the event of an avalanche rescue. Four is a good number. Skiing alone leaves no margin for error and is not a good idea in avalanche terrain.

Ability

Because a good skier making smooth turns stresses a slope much less than a falling skier. You should match your skiing ability with the steepness and stability of the slopes you ski. A skier who has a tendency to "crash and burn" on steep slopes should not ski steep powder of dubious stability. There are some experts who consider that to ski deep powder in marginal conditions you should be able to "parallel" ski, as "telemarketing" puts a greater stress on the snow!

Safety Equipment

It is probably stating the obvious to point out that if you are a deep-power fanatic you should possess, carry and know how to use basis safety and rescue equipment. If you get into trouble, self rescue is your only hope. Make sure that all your party members have working avalanche beacons and are proficient in their use.

Local Knowledge

Your margin of safety will be much higher if you ski slopes you know well, then if you ski a new area. If you ski regularly in the same area over a period of years you will learn which slopes can be safely skied in different snow conditions and which slopes are prone to avalanching. You will get a feel for the area so that your observations of conditions will become keener. The importance of local knowledge cannot be overstated.

Form an Opinion on Snow Stability

If you are skiing in your local area and have followed the build-up of the snowpack and recent changes in weather, you should be able to form an opinion, no matter haw rough, about current snow stability. Build up an overall picture as the winter progresses and revise and refine this picture every time you go skiing. Choose your destination for the day with this picture in mind, and as you approach your chosen slopes compare your stability prediction with actual snow conditions. Do not let your desire to ski a slope interfere with your evaluation of its stability.

Snow, Avalanche and Weather Reports

In many areas you can obtain up-to-date avalanche forecasts prepared by professional forecasters. While these reports are usually for large regions or even for whole mountain areas, in times of high or extreme instability they will sound a warning bell. They will often indicate the conditions which are causing instability such as persistent buried surface hoar or wind loaded slopes of a certain aspect. Along with a call to the weather office a call to your nearest avalanche forecast centre or to park rangers and wardens is one of the prerequisites for safe skiing. In Canada call 1-800-667-1105

for the Public Avalanche Information Bulletin put out by the Canadian Avalanche Association.

Wait for the Right Conditions

Successful (surviving) extreme skiers make meticulous preparations and wait for exactly the right conditions before making their descent. Following their example, you should wait for the right conditions before skiing a particular slope or gully. Be flexible in your choice of slopes; if conditions are not right, go somewhere else. Timing is everything!

Snowcraft

Snowcraft is a little used term for an almost lost art. Anchorage avalanche educator, Doug Fesler, calls it "wearing your avalanche eyeballs". Like navigation it is the art of observing, storing and compiling into a picture a multitude of minute details. Observation is the key to safe travel in avalanche terrain - observation not only of the mountain scenery but of the multitude of clues indicating snow conditions visible to the perspective traveller. Observation is a major factor in evaluating the stability of a snow slope. Some of the things you should look for are as follows:

Evidence of Avalanching

This is the most important clue to instability you are likely to be given. Use other slopes in the area as indicator slopes. If nearby slopes have avalanched, observe how much snow has come down, how far the slides have run and the depth of the fracture line if they are slab avalanches.

In particular, look for recent avalanches on slopes of similar aspect to those you wish to cross. New snow sluffing off cliffs or snowballs rolling down steep slopes are either an indication of settling and strengthening of the snowpack or of isothermal conditions developing.

Wind Direction

You must always be aware of the direction from which the wind has been blowing and its approximate strength. Snow blowing off ridges, cornices, rime, drifts and around rocks and trees are all good indicators. As a general rule the more pronounced the feature the stronger the wind. Knowledge of wind direction and strength will enable you to decide if you are on a lee slope and likely to encounter slab.

Aspect

The aspect of a slope to both sun and wind is most important. If you've ventured onto a lee slope, look for layers of soft or hard slab. On a spring ski tour watch the shadows; when they point to a slope like a warning finger the slope is receiving the maximum amount of heat. In depth hoar country, a north slope may consist of little but loose highly unstable sugar snow crystals early in the winter.

The Snow Surface

Observe the texture of the snow surface and note any changes. Is it just a local effect caused by wind or are you on a slope of different aspect? Look for wind or sun crusts, surface hoar, riming or convex furrows which are signs of rain. Some snow surface features like etching and rippling indicate previous wind direction.

A good guide depends largely on "feel". The "feel" of the snow beneath his skis as he turns and a "sense" of terrain. His built-in wealth of experience attunes him to anticipate potential problems as he skis various types of terrain just as a good driver senses potentially dangerous situations

developing around him on the highway.

Feel the snow with your skis to detect any changes to hardness or texture. If you are following in the tracks of other skiers, step out of the trail occasionally. If there is fresh snow, check the depth as you ascend and evaluate how well it is bonded to the old snow surface. In cold snow, cracks running ahead of your skis are a sure sign that you are standing on slab; an important warning of instability which must not be ignored. Keep your eyes open and your senses alert. Gather as much information as you can.

Settling

One feeling which everyone will recognize once it has been experienced is the scary sinking feeling as slabs sink underfoot. Sometime this is a gentle subsidence, sensed rather than felt; a slight setting which produces no visible signs at the snow surface.

This is a sure indication of soft slab. If you're on a steep slope when the setting occurs you'll be relieved to know that the snow has settled without avalanching. But ten paces on it may avalanche rather than settle. It's your decision; retreat or risk it.

As snow slabs become harder, settlement will be more pronounced and you will actually feel the drop. There will be an audible "whumph" and often some visible sign of settlement on the snow surface such as dishing or cracking.

Movement of Skis

The way in which your skis move through the snow is another indication of snow conditions. If your skis tend to skid sideways you may be on a crust, hard slab or ice. If your skis subside gently into the snow as you break trail, but are hard to push forward or lift out, you are probably skiing in soft slab. When your skis or crampons ball up in new or settling snow it's an indication of a rise in temperature. Consider how much the temperature is rising and the effect it might have on the stability of the snowpack.

Weather

Don't forget to observe the weather. Changes in weather, particularly heavy snowfall , current wind speed and direction or a sudden rise in temperature all have an important effect on snow stability.

Test Slopes

Small, steep slopes along your route will give some indication of stability. Try to ski them off or jump on the top of them. Jump on cornices as long as you can do it safely. A good sized chunk of cornice rolling down a slope without triggering a slide will give you a lot of confidence in a slope's stability.

Ski cutting the top of large slopes is a much dicier business and should be done with caution. Never ski cut below a cornice. A snowboarder became the first snowboard avalanche fatality in Canada by doing this.

Ski Pole Test

The ski pole test is a means of checking snow layers in the top metre or so of the snowpack. It consists of pushing the pole into the surface at a controlled rate and feeling the changes in resistance as various snow layers are encountered. Although used to check for specific indications of hazard such as hard slab and depth hoar, it should never be used as the sole judge of snow stability, but rather as an indication that snow conditions have changed and that further testing is desirable.

Ski pole tests should be carried out regularly in avalanche terrain; often a seconds pause is

enough to detect a significant change in the snow. Before venturing onto a large slope, test a small slope of the same aspect first, making sure the elevation is as close as possible to the estimated trigger zone of the large slope.

Snowpits

Dig a snow pit on a test slope in a safe location. It is usually not necessary for the backcountry skier to dig more than about 1.5 to 2m deep. You really have no way of evaluating deep instability and if deep instability is forecast by your local avalanche warning centre you should be skiing somewhere else; somewhere safe.

According to Bruce Tremper, a professional stability forecaster, "The name of the game is to dig a pit in the most representative spot you can choose without getting killed". You may have to settle for a smaller test slope, and try to extrapolate the results to the larger slope, or work your way in towards the middle of the larger slope, digging several quick pits and retreating if there is any indication of instability.

In order to get reliable results, take care when choosing your snowpit locations. Stay away from trees; avoid drifts or ridges where the wind may have altered the layering of the snowpack; be aware of rockbands, buried bush or other shallow spots and avoid breaks or transitions in the slope. The ideal location is in the middle of a steep, open slope!

As you dig, pay attention to the consistency of the snow. You can learn a lot about the composition of the snowpack during the digging process. In warm conditions (close to 0 degrees C) find the temperature of the snow. You are looking for snow which is within a degree or two of freezing point. This is the layer which might slide as a wet snow avalanche. Look in particular for clusters of large wet incohesive ice grains which indicate the advanced stage of MF-metamorphism (commonly called rotten snow).

Feel the snow with your gloved hand to get an idea what layers are present in the snowpack. Don't bother with brushes or credit cards or with looking at the snow crystals with a magnifying glass. All you are trying to see is the overall picture. Look for the weakest layer and try to estimate how well it is bonded to the adjacent layers.

Shovel Shear Test

Do a Shovel Shear test looking for weak layers, especially layers of buried surface hoar. Remember that the shovel shear test is a good way to identify weak layers in the snowpack but a poor way to evaluate its stability. Make sure you know how to do it correctly. The way you cut the back of the column is critical.

The shovel shear test must be done on a slope with the same orientation as the potential avalanche slope and as close to the elevation of the trigger zone as possible. The following procedure is suggested for use in the back country.

1. First, probe to determine the total depth of the snowpack and to get an idea of the layering. By doing so you can find out the extent of thick layers of potential slab and any weak layers underneath.
2. Dig a snow pit about 1 meter wide and as deep as you think necessary from knowledge gained from other observations. It should be at least as deep as the most recent snowfall, with a practical maximum of about 1.5 m. Observe the layering of the snow as you dig, especially the hardness, crystal type and free water content of significant layers.
3. Trim the uphill wall of the pit so that it's vertical.
4. Excavate a chimney in the uphill wall about a shovel's width wide and just over a shovel's width

into the hill.

5. Mark on the snow surface a square block with sides 30 cm to 35 cm (a wide shovel's width) at the side of the chimney.
6. Using a snow saw or the tail of a ski, cut out a triangle of snow at the other side of the block.
7. Make a vertical cut at the back of the block about 0.7 m (2 shovel widths) deep or, if you have an indication of the depth of a weak layer, cut down to just below the suspected layer. Do not cut all the way to the bottom to start with and do not cut down into depth hoar or the block will collapse.
8. Carefully insert the shovel to its full depth at the back of the block, then using both hands and without levering pull gently on the shovel handle. Cut down the back of the block another 0.5 m and repeat the test.
9. If a significant sliding layer is present the block will shear off in a smooth even plane. If the block doesn't slide off smoothly the test is invalid and must be repeated.
10. Examine the fracture surface and try to determine type and size of the snow crystals causing the sliding layer.

The primary reason for doing a shovel shear test is to identify weak layers or lack of bond between adjacent layers within the snowpack. It is possible, with experience, to estimate the strength of shear of the weak layer or interface. However, any estimation of the shear strength should only be used as an indication of the need for further testing.

If the block slides during cutting or insertion of the shovel, then obviously there is a very weak sliding layer present. If there is a significant depth of snow above the sliding layer you should be looking for other signs of instability in the area and should be very wary of skiing steep slopes. Continue testing down the block looking for other weak layers.

If the block slides off with pressure from the shovel - remember it must exhibit a clean, smooth shear to be valid - and if there is more than 15 cm of snow above the sliding layer, a Rutschblock Test is certainly indicated.

It is not uncommon in cold dry climates with a shallow snowpack for the block to collapse into the depth hoar layer as it is cut. In this case, you must decide if the overlying snow structure is strong enough to support itself over the top of the depth hoar. If you have any doubts about the strength of the snow above the depth hoar, try the Compression Test described below.

Compression Test

Use this test if you suspect slab and where there's a layer of depth hoar at the bottom of a shallow snowpack.

Proceed as for the Shovel Test, but do not cut into the back of the block. Cut the sides down into any depth hoar layer. Now place the shovel flat on the top of the block and bear down in an attempt to break the cantilevered slab and collapse the layers underneath.

The force required for failure will give you an indication of both the ease of collapse of a depth hoar layer and the strength of the slab. Slab strength is a most important factor in an early season snowpack underlain by depth hoar.

Loaded Column Test

Do a Loaded Column test to identify the weakest layer and to get an idea of how much weight can be applied to the snow before it fails. The Loaded Column Test must be done on a slope of at least 30 degrees.

1. Isolate a column as for the Shovel Shear test, but for this test, cut the back of the column right down to the bottom.
2. Flatten the top of the column.
3. Cut blocks about the same sizes as the top of the column, and pile them onto the column until the column fails (or it is obviously not going to fail).

Interpretation of Results

The theory behind this test is that if you can add 50 cm of reasonably dense blocks, say about 30% density, then the slope could be loaded with the equivalent amount of new snow before it would fail. For instance, if the new snow density is 10%, then 150 cm of new snow would be needed before failure.

In practical terms, proponents of the test feel comfortable skiing a slope if they can pile on 70 cm of reasonably dense blocks without the weakest layer failing.

Rutschblock Test

Do Rutschblock test as a practical evaluation of stability and as a means of filling in your snowpit as a courtesy to other skiers. If you find no significant instability, work your way out onto the edge of the slope you wish to ski, probing with ski poles as you go to determine if the consistency of the snow and the makeup of the layers remains the same. Do another quick series of tests. Depending on what you find you may wish to stick your nose farther out onto the slope, or you may decide to retreat.

1. Select a site as close as possible to the slope you wish to ski, and of the same aspect. If you must do this test on slopes of less than 30 degrees, the lower wall should be as smooth as possible, and a second person should watch for small displacements (less than 1 cm) that indicate shear failure.
2. Dig a pit and completely isolate a block about 2 m wide (a ski length) by 1.5 m deep using a combination of shovel, snow saw, ski tail, or knotted rope; whichever is the quickest. Flare the side cuts a little so that the block is free to slide out.
3. Load the block in the following sequence and observe when a clean fracture takes place.

Loaded Steps:

1. The block slides as it is being cut out.
2. Put skis on and carefully approach the block from above. Step down with one ski onto the block close to the upper wall. Transfer your weight carefully and place the other ski on the block.
3. Flex your knees quickly, without lifting your heels, to transfer your weight to the snow, thus compacting the surface layers.
4. Jump up and land on the same compacted spot near the back of the block with both skis.
5. Jump onto the same spot a second time.
6. Either jump on the same spot on the block without skis or repeat steps 3 and 4 with skis on, landing in the middle of the block.

Interpretation of Results

Conservative backcountry skiers will not ski a slope if the Rutschblock test fails with less than 2 jumps (step 5 or earlier). If the snow fails at any time before you jump on the block, instability is considered to be high on slopes of similar aspect and steepness.

If it fails when you jump on the snow with skis on, local instability should be suspected on similar slopes.

If you have to jump on the block with skis off or jump on the middle of the block to get failure, or if there is no failure, there is a low risk of avalanches.

Limitations

The Rutschblock test will not identify weak layers above the layer penetrated by your skis during the test. For instance, if you sink 20 cm into the surface snow when you step onto the block, a weak layer at 15 cm may not be apparent. The test has been found to be most effective on slopes greater than 30 degrees.

Summary of Procedure for Stability Evaluation

- Form an opinion on current stability from your home.
- Call the avalanche hotline for your area.
- Pick the area in which to go skiing based on the above opinion.
- Observe slopes visible from the road as you drive to your destination.
- Decide the slope you are going to ski when you get to the area and have had a chance to evaluate stability.
- Determine the angle of your intended slope. Is it 35 degrees or steeper?
- Practice the fundamentals of snowcraft.
- Jump on small, steep test slopes along the route to see if they slide.
- Jump on cornices as long as you can do it safely.
- Dig a snowpit on a test slope in a safe location.
- Pay attention to snow consistency as you dig.
- Run a gloved hand down the pit wall to get an idea of layering.
- Look for the weakest layers.
- Do a Shovel Shear test to identify weak layers.
- Do a Loaded Column test to identify the weakest layer and to estimate how much weight can be applied to the snow before it fails.
- Do a Rutschblock test as a practical evaluation of stability.
- Probing with ski poles as you climb to the top of your chosen slope to determine if the consistency of the snow and the makeup of the layers remains the same.
- If in doubt do another series of tests.
- Practice "Safe Skiing" techniques.

Safe Skiing

"The first rule of thumb in safe skiing is, if your partner wants to ski first...let him!"
—Brad Meiklejohn

After stability evaluation the best way of "Reducing the Odds" is to practice safe skiing techniques. There is one overriding rule for safe skiing and that is; never expose more than one skier at a time to avalanche danger. The following are pointers gathered from ski guides, avalanche professionals, extreme skiers and backcountry ski fanatics. One thing all these people have in common is that they are willing to turn around and go home if they become uncomfortable about the level of risk.

Managing Your Party

- Plan your descent. Decide where on the slope you will put the first track, who will ski first, which side of the first track the second skier will ski and how far down the slope you will ski before stopping to regroup. Stop at the very edge of the slope or ski right to the bottom.
- If the entire run is not visible, stop (to the side) at any changes in steepness or direction and ski the new section as a separate slope.
- Ski one at a time and watch each skier for the entire run. Don't start until the previous skier is out of the way. Skiing one at a time keeps the stress on a slope to a minimum.
- Don't ski above one another. Take care when tree skiing or skiing rolls and bumps not to ski above your partner. Move well to one side or to a safe position following the run.
- Use the buddy system and stay within sight or sound of your buddy at all times.

Skiing the Slopes

- Start the day by skiing easier angled slopes and work your way onto the steeper slopes. Ski treed slopes before open ones.
- Typically the first run of the day is always a safe run with several test locations for stability evaluations; a small steep roll or short commonly wind-loaded slope. Continue to sniff around, being constantly aware of changing weather and snow conditions.
- Start skiing a slope at the sides, working toward the centre on successive runs.
- Ski on ridges instead of bowls: stay out of gullies and avoid skiing slopes which channel into gullies; be alert for terrain traps.
- Enter the slopes at the top rather than at the sides. Don't ski in from the side below a cornice.
- Take a good look at the slope and consider the possibility of "weak spots". Ski where the snowpack appears to be deepest, avoiding possible "weak spots". In depth hoar conditions stay away from rocks which may be trigger points.
- Ski as smoothly as possible and in control. Sit down rather than crash.
- Ski the slopes as often as you can throughout the season. This not only gives you an intimate knowledge of the terrain, but also ski packs the snow, reducing its potential for sliding.
- Put your climbing track on safe, low-angled slopes. Climbing straight up on foot should only be done on the most stable slopes.

- A new lesson learned from heli-skiing is to look well above and contemplate triggering an avalanche that starts a long distance away.

Weak Spots

It is possible that, on any given slope, the strength of a buried weak layer, or of the snowpack itself, may vary from place to place.

Consider a slope covered with a certain depth of snow. If the slope were perfectly even, you would expect the snowpack to be uniform across the slope. However, if the slope is uneven or if there are buried rocks or brush, then the temperature gradient in those areas will be different and the snowpack will no longer be uniform. In climates where recrystallization is taking place such areas may be weaker and potentially less stable due to the higher rate of recrystallization. These areas are called "weak spots".

In studying a number of slab avalanches which have been triggered by a person adding stress to a weak layer, it has been noticed that the initial rupture of the slab usually begins in a localized area where the weak layer is at its weakest.

Once failure occurs at the "weak spot", the fracture propagates rapidly throughout the slab into areas of stronger snow; into snow which your companions may have safely descended.

The Implications of "Weak Spots"

The farther down the weaker layer is in the snowpack, the less likely you are to trigger an avalanche, therefore you should try to ski where the snow cover is deepest and keep away from rocks or brush protruding from the snow. On suspect slopes, follow the exact line taken by the person in front.

Remember that the more you concentrate your weight in a small area the more stress you transmit to the snowpack. A snowboarder will add less stress to weak layer than will a person on skis. Taking your skis off and walking down a slope is a dubious technique when slab conditions are suspected.

The old concept of moving between "islands of safety" needs revising to stress that the "islands" should be large and solid. A substantial clump of trees or a solid rock buttress, rather than insubstantial objects such as small trees or bush sticking up through the snow.

Tony Daffern is the author of Avalanche Safety for Skiers and Climbers.